Loads and Dynamics TDT
Micro Burn Wire Release Mechanism

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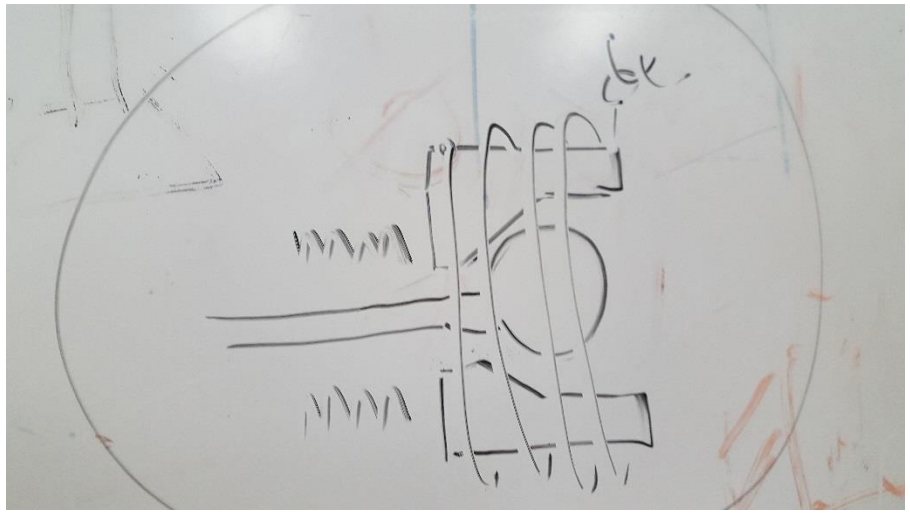
Project Introduction

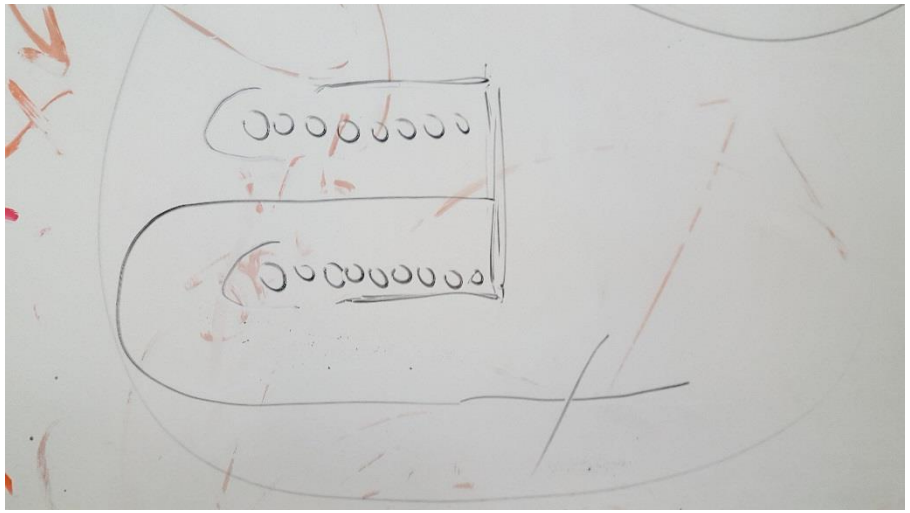
- Last minute, mission critical release mechanism failure
- One path pursued to identify and correct the problem with the original mechanism
- Second path pursued to make a new mechanism and deliver it to the flight S/C in 8 weeks
- First step was negotiating acceptable risks
  - No material certs
  - Minimal official documentation; engineer discretion
  - Proto-flight development
  - Requirements solidified in <2 days (much easier later in the mission)

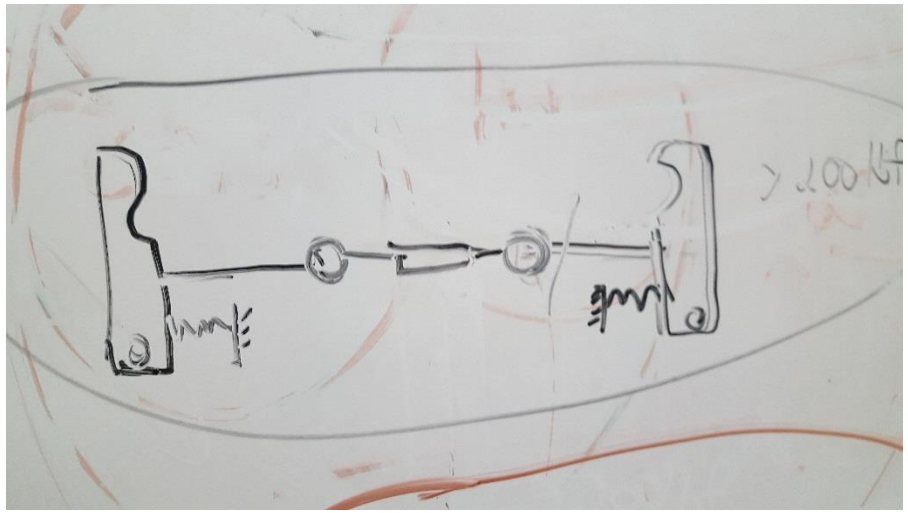
Trade Study – Trigger Mechanism

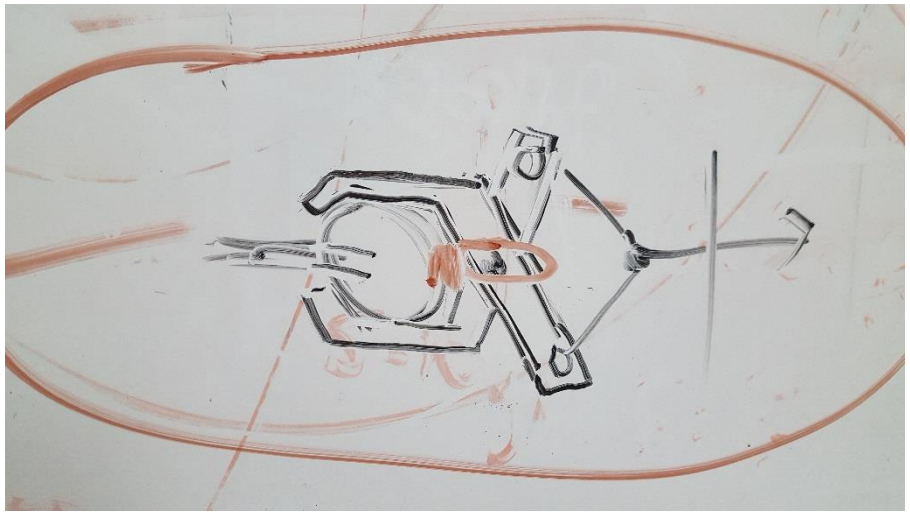
- Burn Wire
  - Fewest moving parts
  - Easy redundancy
  - Short Lead time
  - Works with electrical requirements
- Shape Memory Alloy
  - Used for failed design (fresh wounds)
  - Simple to actuate
  - Works within electrical requirements
  - Less experience
  - Short Lead time
- Split Nut
  - Very Reliable
  - Long Lead
  - Simple to actuate
  - Extensive flight heritage

Trade Study – Mechanical Advantage?

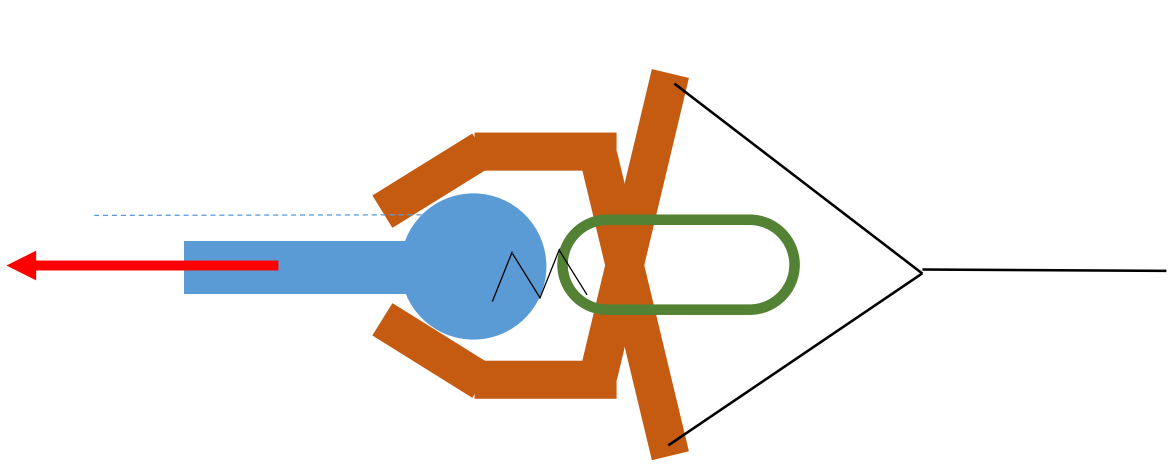


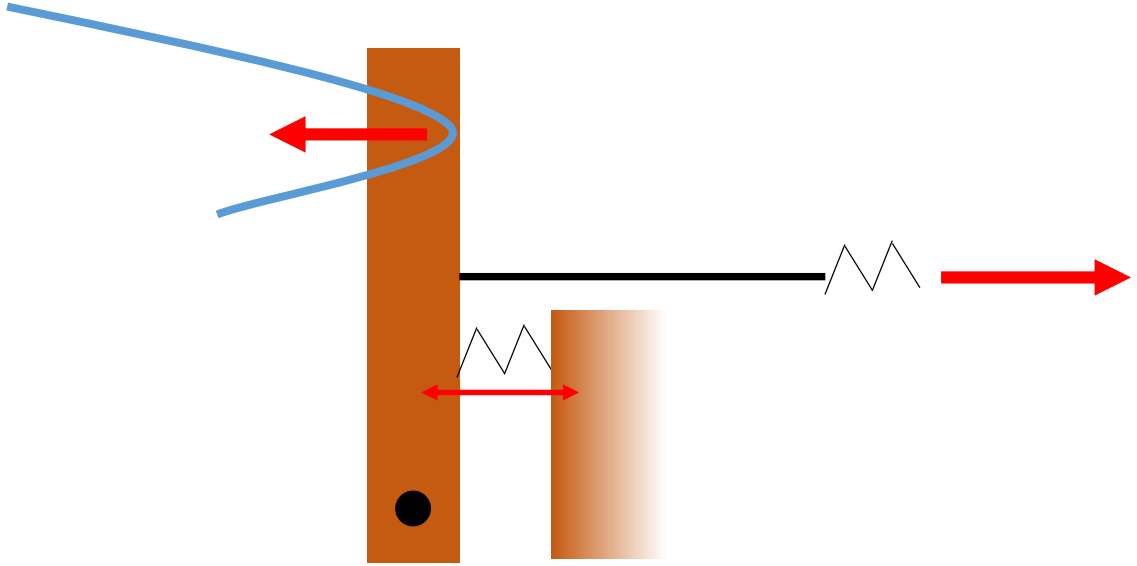


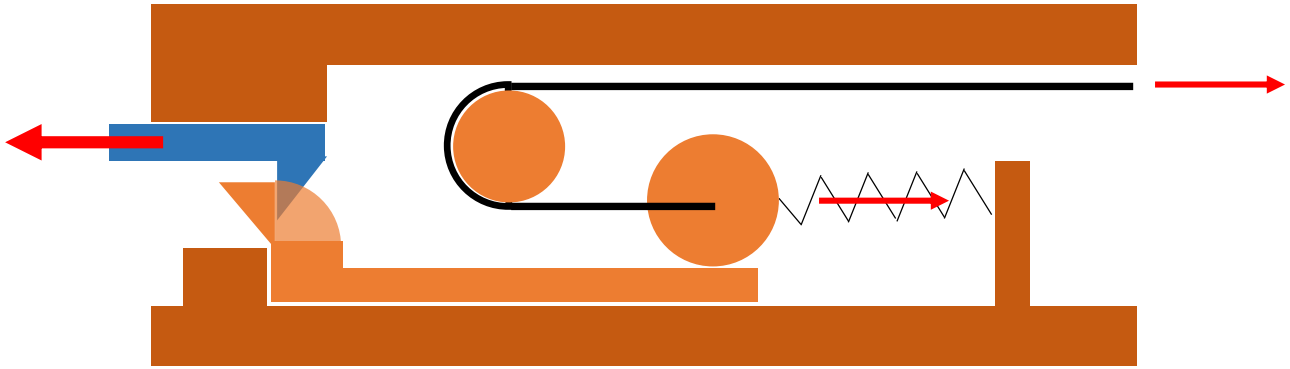




Trade Study – Mechanical Advantage?

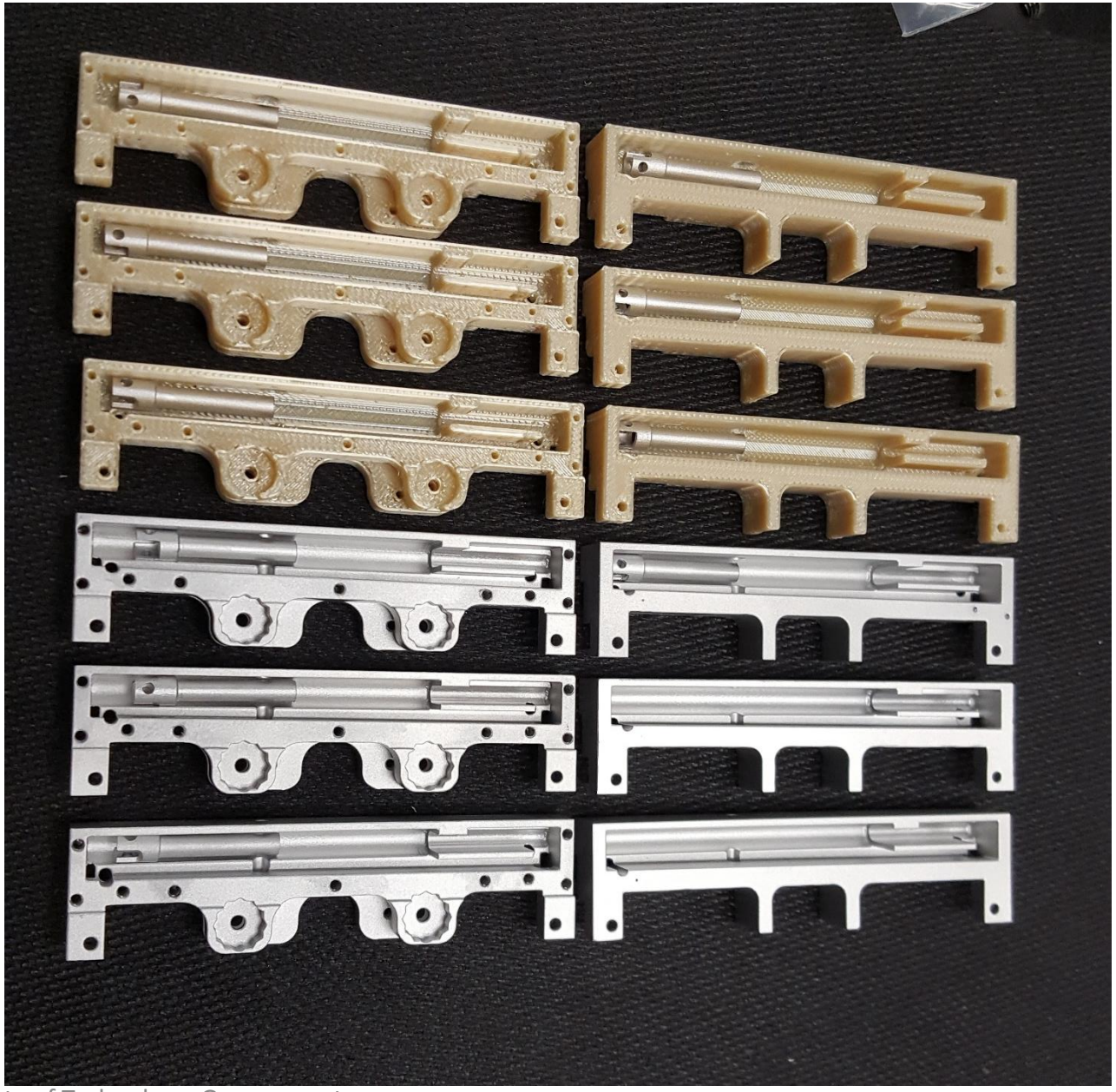






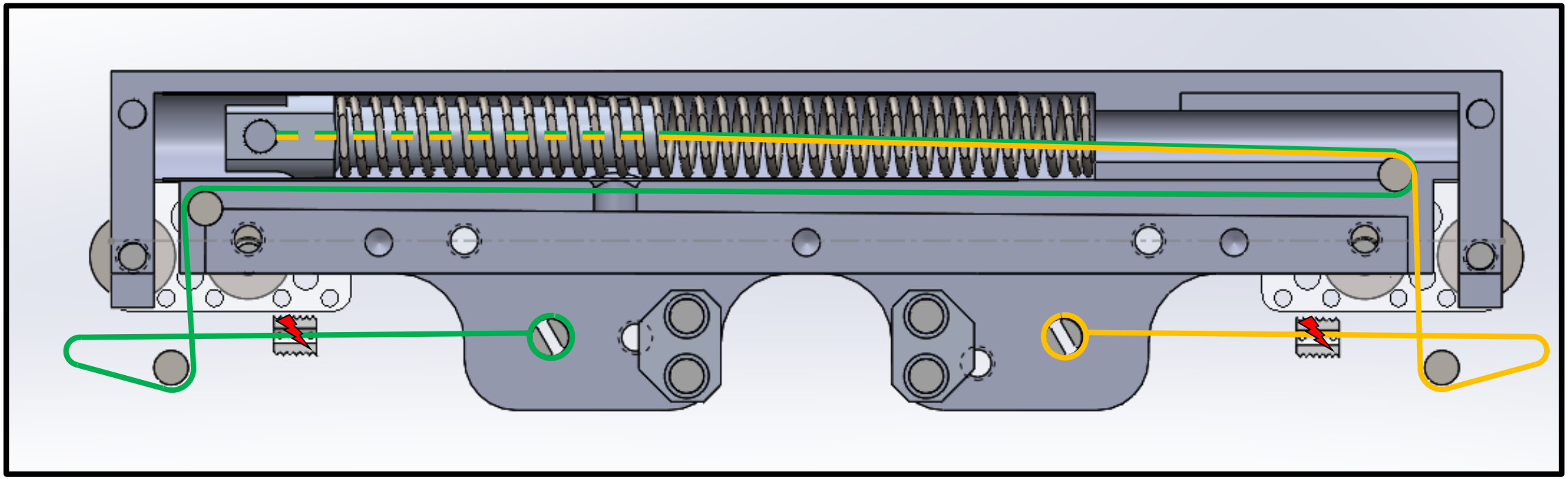
Proto-Flight

- Concurrently test several prototypes with the assumption that any of them can become flight. Down select through early, often testing.



Trade Study – Mechanical Advantage?

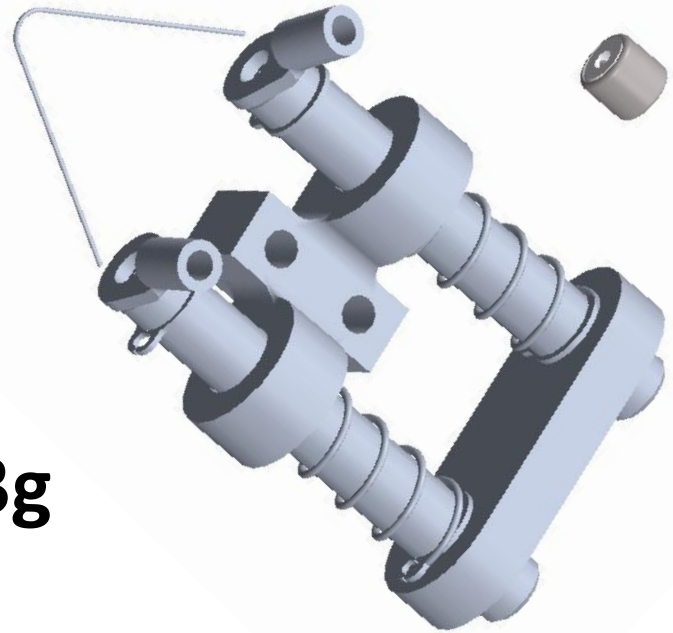
Testing showed it was not necessary: favor fewer parts



Intro

This document is intended to provide a comparison of the advantages and disadvantages of the JPL Micro-Burn Wire release mechanism and the NRL Cubesat Burn Wire Mechanism

JPL ~0.05g



NRL ~2.3g

Relative Size Comparison

NRL Cubesat Burn Wire Mechanism

Advantages

- Further in development
- More data available on performance
- Potentially easier to handle

Disadvantages

- Larger
- 46x Heavier
- Moving parts with potential to jam
- L-D ratio is unacceptable per JPL linear slide requirements
- More parts

JPL Micro Burn Wire Mechanism

Advantages

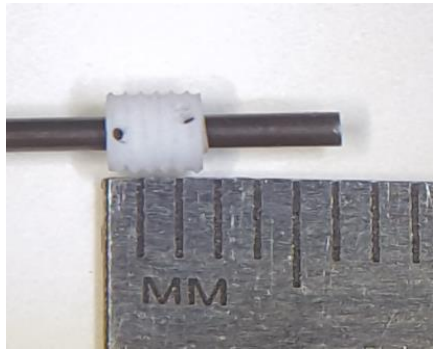
- Smaller
- 46x Lighter
- No moving parts
- Fewer parts

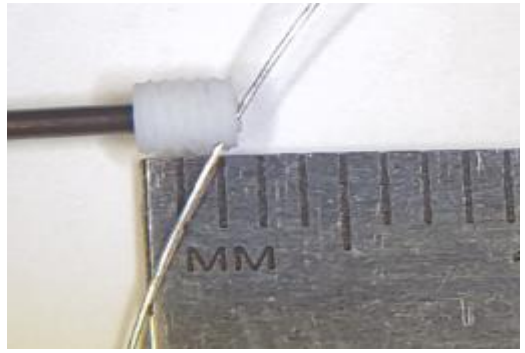
Disadvantages

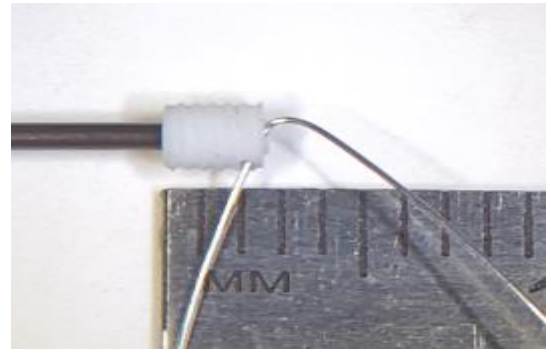
- Not as far in development (has not had a chance to be vibe'd)
- Less data available on performance
- Potentially more challenging to handle

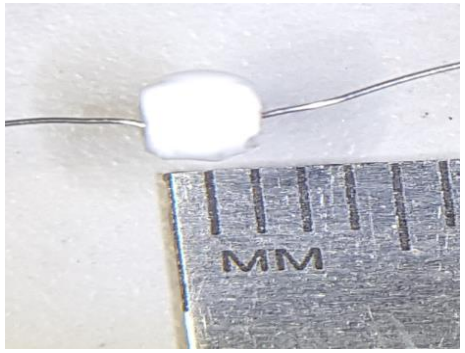
How’s that little thing work?
Is it proven?

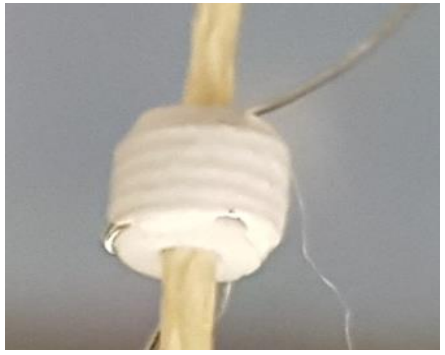
Assembly

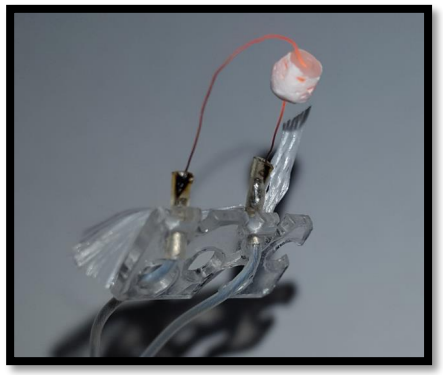




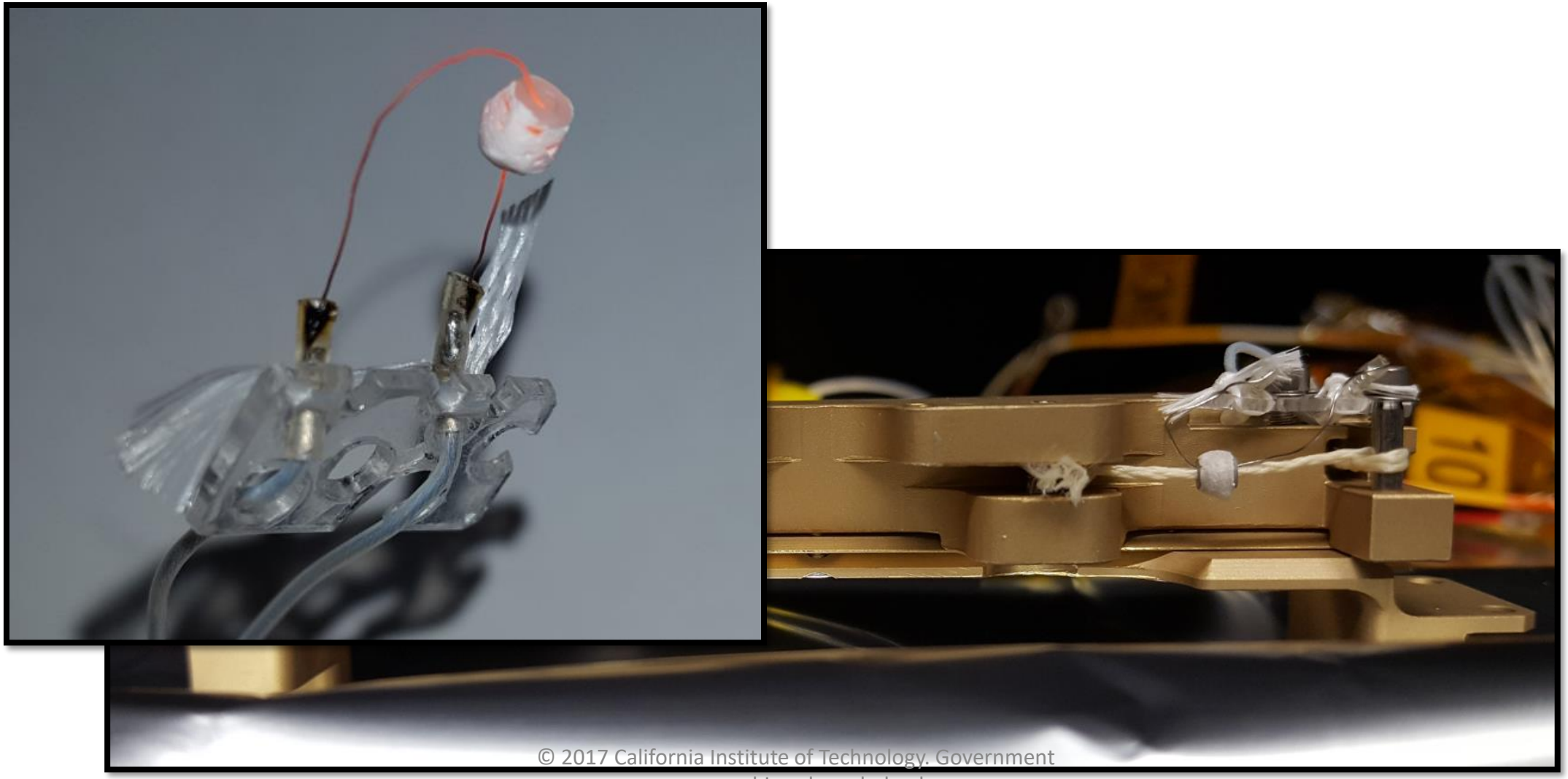








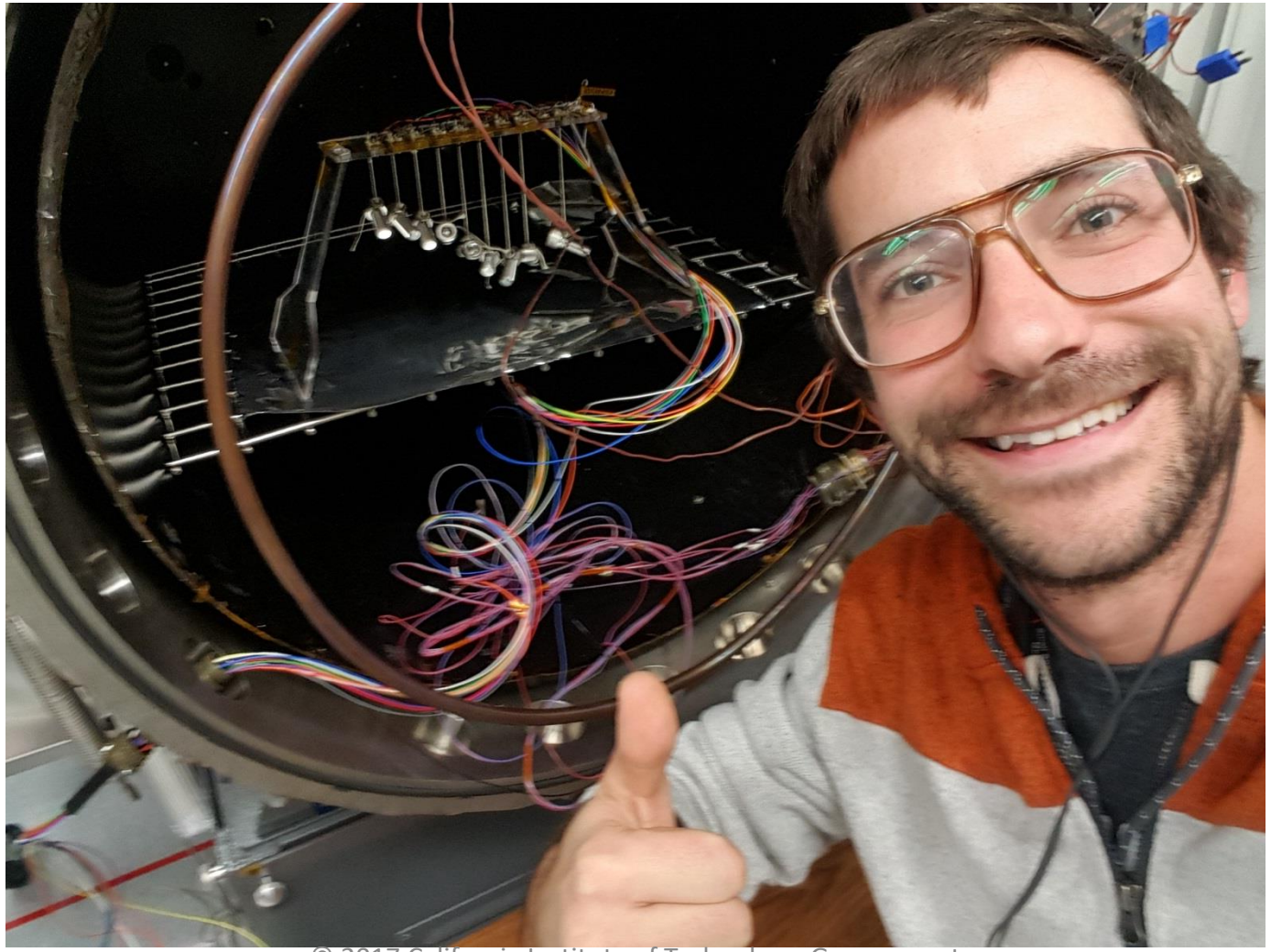
Finished Product



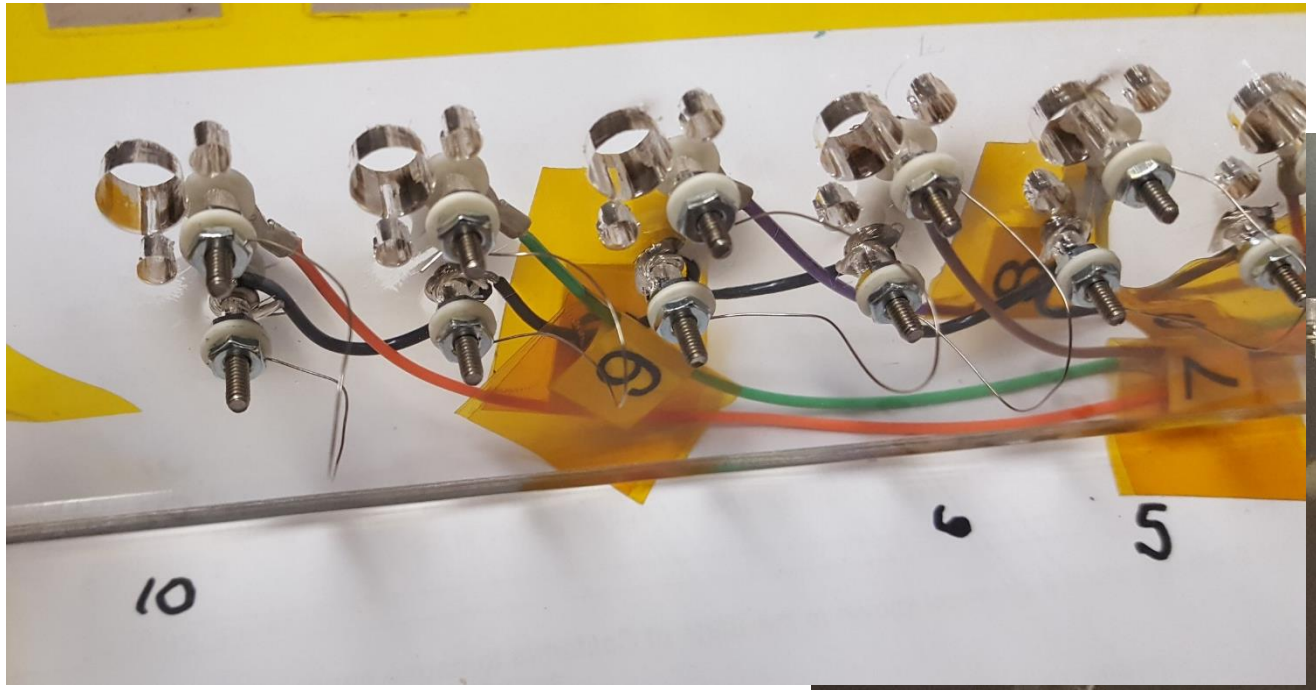
Nichrome Failure Current – Setup / Procedure

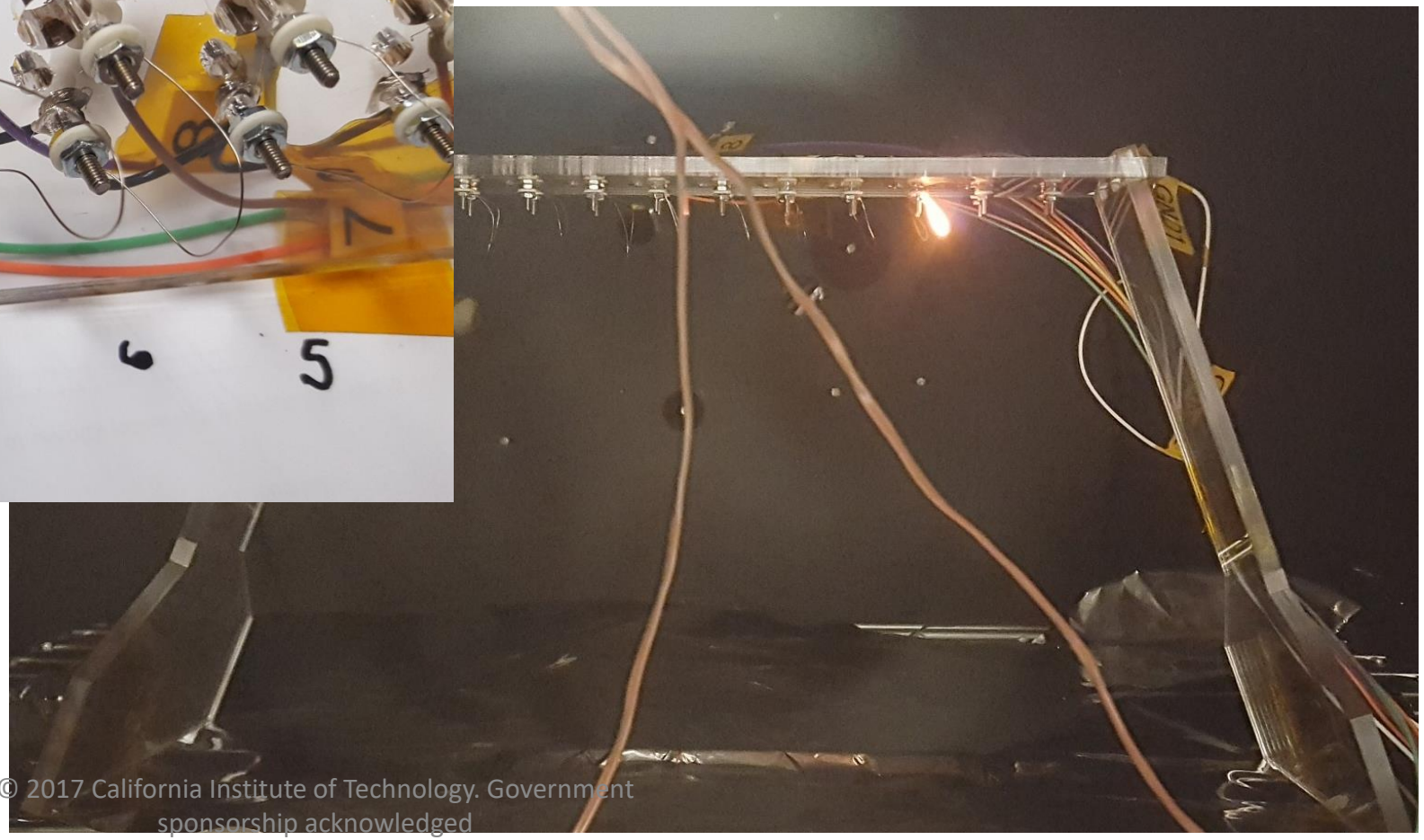
- 5 Nichrome wires of 0.0080” diameter, and 5 nichrome wires of 0.0100” diameter, all approximately 3-5cm length were placed in the vacuum chamber
- Pressure pumped down to less than $1x10^{-5}$ torr
- Ambient temperature
- Calibrated Agilent power supply from Loan Pool was used to increment the current by 0.01A
- Each current allowed to dwell for ~3 seconds before incrementing

Nichrome Failure Current – Let’s Go!



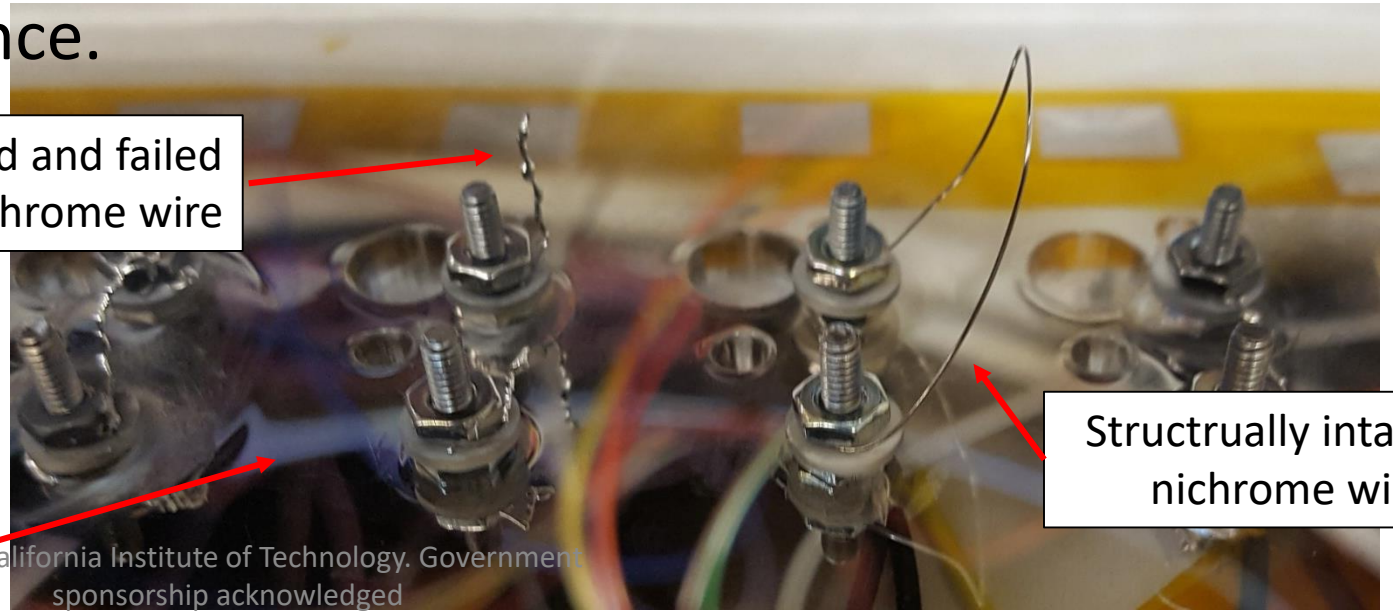
Nichrome Failure Current – Setup / Procedure





Nichrome Failure Current – Data

- Early in this testing it was noticed that the voltage increased with current (as expected) until a certain point when the voltage began to *decrease*. It was observed that the decrease in voltage corresponded with a significant drooping or even shriveling, like melting plastic wrapper, of the nichrome wire. For this reason **"change current"** is used to indicate that instance.



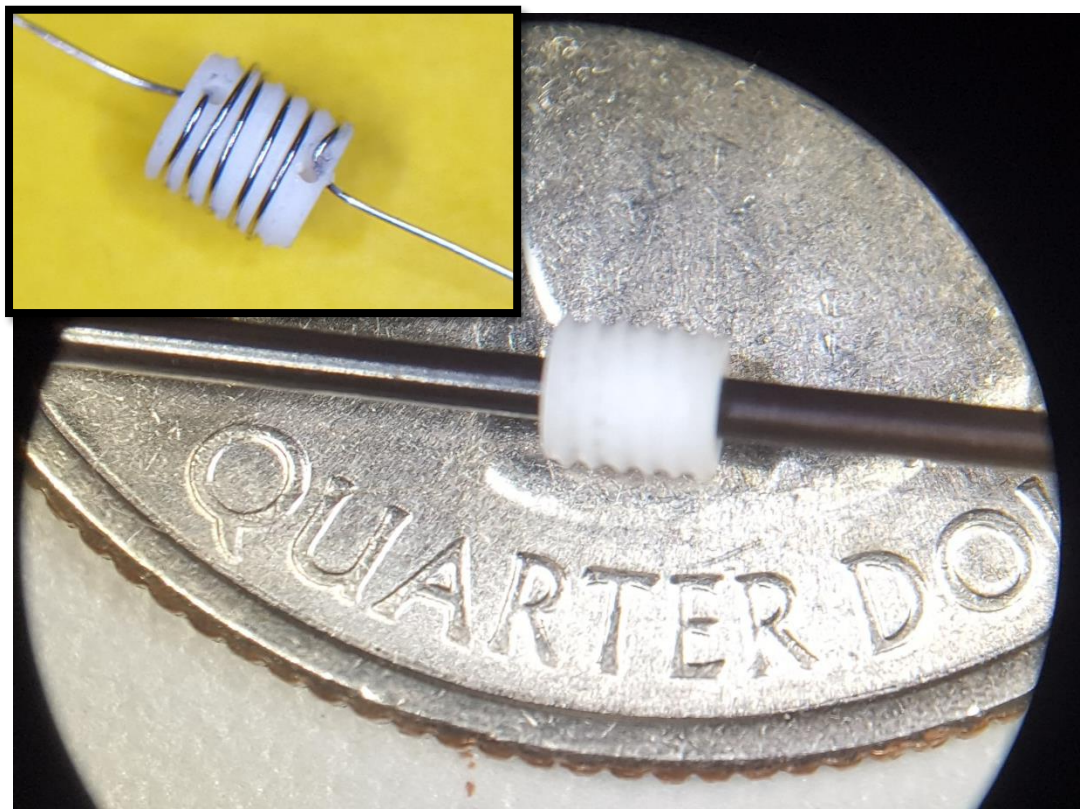
Nichrome Failure Current – Data

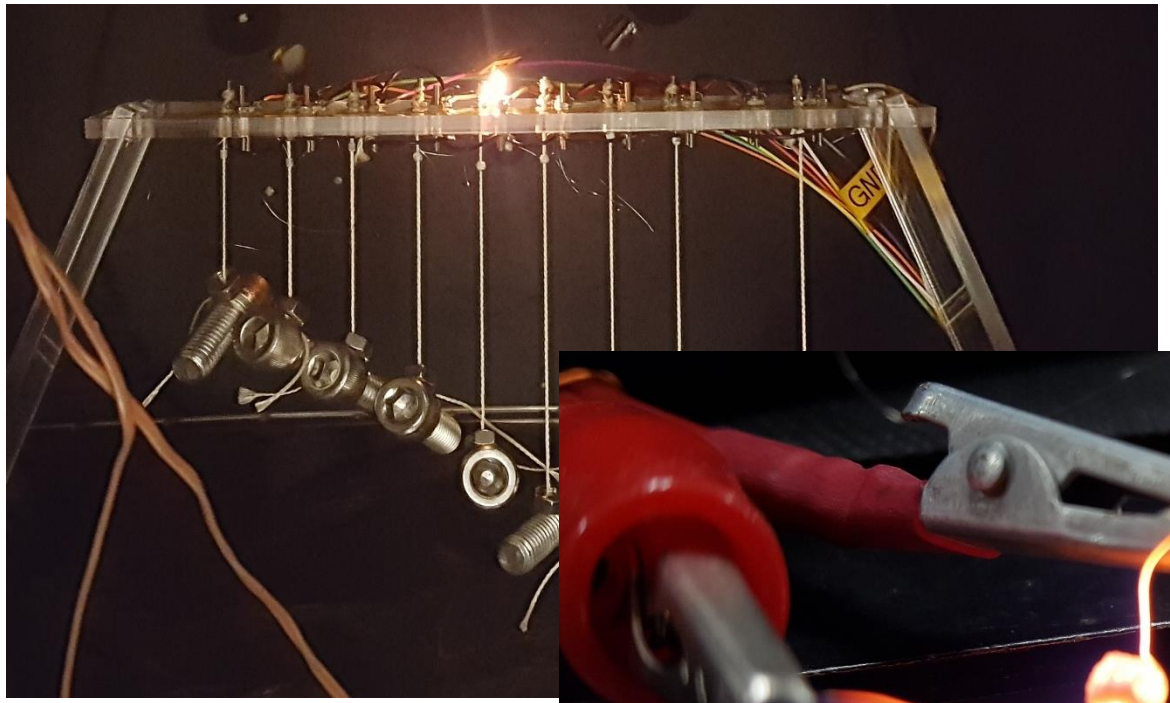
Vacuum Nichrome Burn Wire Failure Tests

0.01A increments, 3 second wait 20VDC limit							
Pressure	1.50E-06 Torr			1.30E-06 Torr, end of test pressure			
Test #	Wire Diam (in)	Screw-screw resistance (ohm)	Change Current (A)				
1	0.0080	1.8					
2	0.0080	2.2	1.42				
3	0.0080	2.8	1.45				
4	0.0080	2.3	1.42	Average	StDev	95%	99.70%
5	0.0080	2	1.39	1.42	0.02	1.37	1.35
6	0.0100	1.4	1.72				
7	0.0100	1.7	2.03				
8	0.0100	1.8	2.04				
9	0.0100	1.6	2.08	Average	StDev	95%	99.70%
10	0.0100	1.6	1.98	1.97	0.14	1.68	1.54

Testing Summary

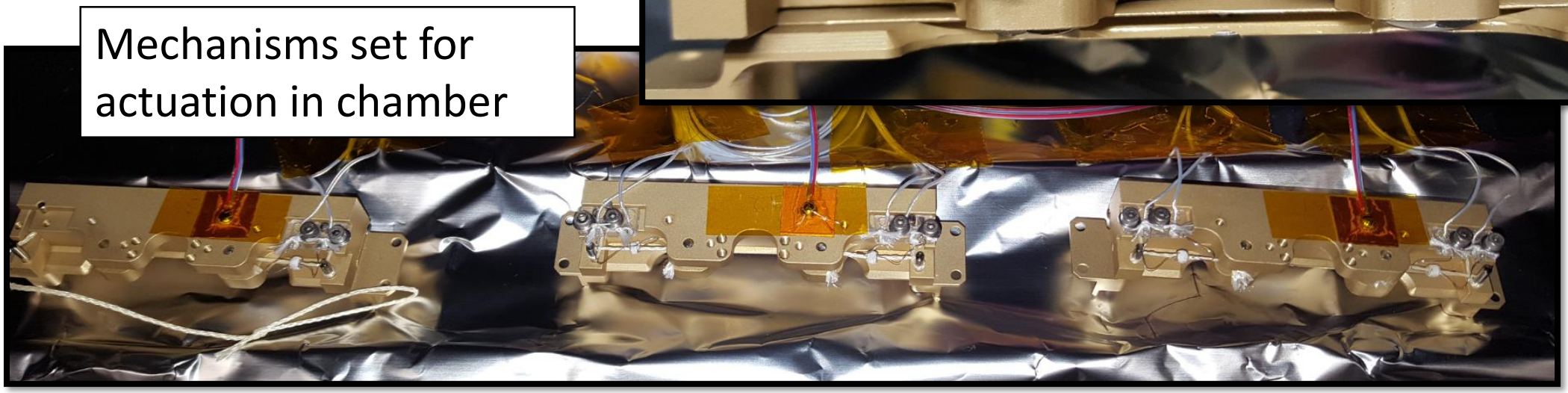
- Successfully demonstrated all requirements except viberation (TBD)
- **51 / 51** successful vectran line melts (ambient and vac)
- **26 / 26** successful vectran line melts in vac
- **11/11** successful full mechanism tests in vac, 3 at <(-20)°C, 3at >(+50)°C



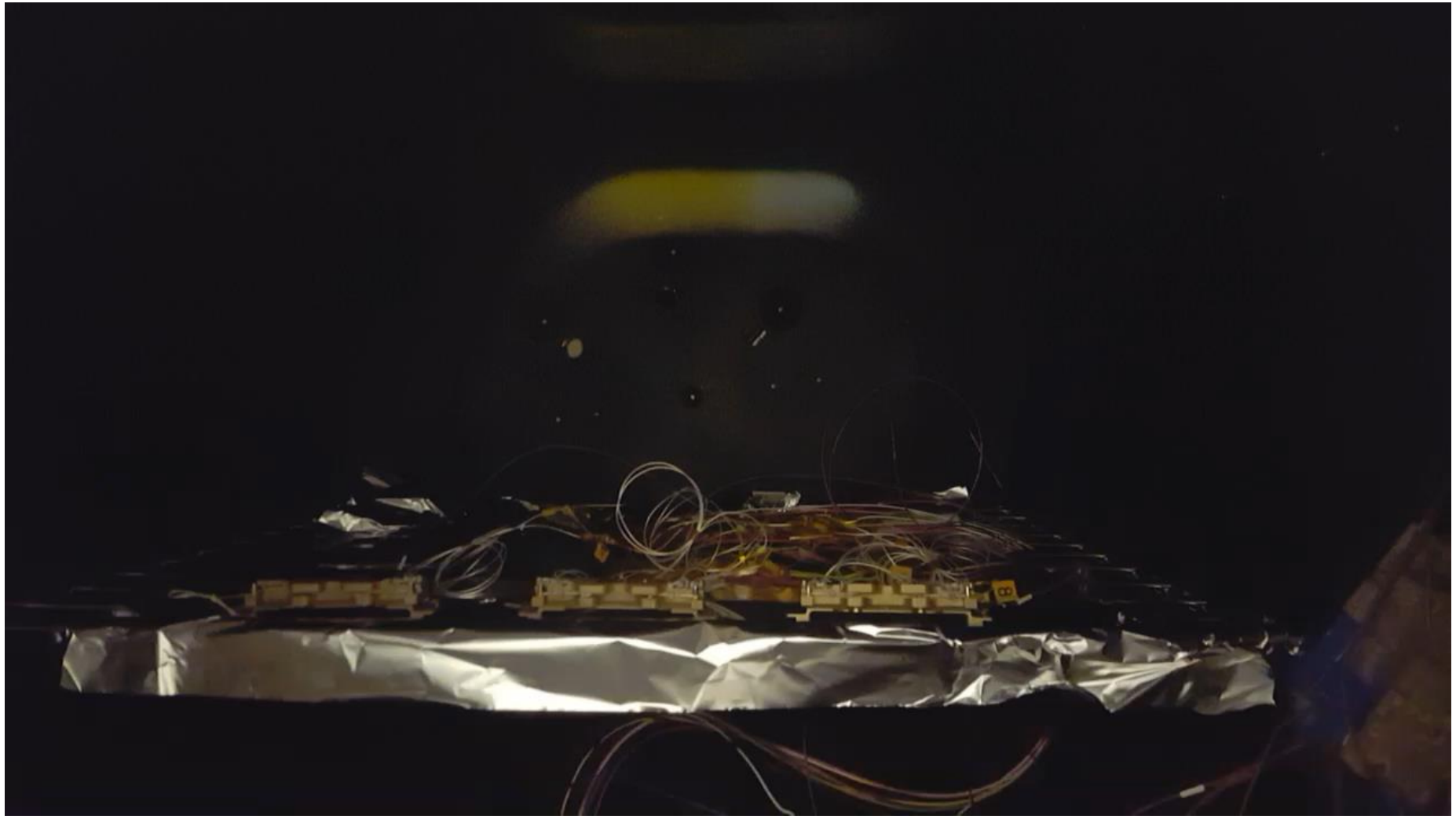


Final Mechanism Detail

- **11 / 11 Successful tests** run with the final design of
  - 0.008” diameter nichrome wire
  - 1.00A current limit
  - vacuum (<10^{-5} Torr)
- **12.5s** average actuation time
- **0.93s** standard deviation



Success!!!



Conclusions

- The Micro Burn Wire mechanism works well.
- It’s not fast, but it’s reliable
- This is among the smallest release devices / release load available
- Open to many options for further increasing the hold load

Acknowledgements

- JPL – always exciting, challenging work
- ETL – great chamber support and flexibility
- Kim Aaron, Chief Engineer – consistent support and assistance throughout the design and test process
- Mike Schein, Chief Engineer – provided the original burn wire concept and suggestions for making it work and improvement
- The Mechanisms Laboratory – Immediate, free access to extensive power supplies, test equipment, load cells, optical tables, etc. which enabled very fast testing
- ISARA – providing a fun and exciting challenge

Questions?

Thank you!